METHOD FOR ALLOCATING CHANNELS, AND BASE STATION APPARATUS AND COMMUNICATION SYSTEM UTILIZING THE CHANNEL ALLOCATING METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the channel allocating technologies, and the base station technologies and communications technologies utilizing the channel allocating technologies. The present invention particularly relates to a channel allocating method according to the type of application used in a terminal, and a base station apparatus and its communication system utilizing the channel allocating method.

2. Description of the Related Art

Various types of non-voice communications such as the transmission of images are in practice owing to the growing multimedia services. The amount of information in this non-voice communication varies, but there is a basic demand where the variation in the transmission time be minimized. For example, if the reproduction of the moving image streaming is to be carried out in the non-voice communication, the amount of information in the moving image data varies according to the variation of the images, so

that it is desirable that the variation in the transmission time be minimized in order for the images to be smoothly reproduced at a receiving end. In addition to the transmission time, it is also required that a predetermined

5   transmission quality, namely, the so-called communication quality be satisfied.

As an approach for meeting the above-described requirements, there is available a method in which the transmission speed between a base station apparatus and a

10   terminal apparatus is determined according to the amount of information to be transmitted, namely, the size of a packet. That is, the transmission rate is raised as the packet size becomes large whereas it is reduced as the packet size becomes small. Thereby, the variation of transmission time

15   between the base station apparatus and the terminal apparatus is kept small. Reference (1) in the following Related Art List serves as an example for such a conventional method.

Related Art List

20   (1) Japanese Patent Application Laid-Open No. 2002-374321.

In a case where the information to be handled by the non-voice communication is the moving image streaming, desired is the smaller variation in the transmission rate. In the case of video conference, it is further requested

25   that the transmission time itself be generally small. On the other hand, if the information to be handled by the

communication is data for file transfer or Web browser, the accuracy of transmitted data is most critically required rather than the transmission time. In this manner, the requirements for the communication quality differ according to application used in the terminal apparatus. In general, the base station apparatus connects a plurality of terminal apparatuses by multiplexing, and communicates with them by allocating predetermined channels to the respective terminal apparatuses. Thus, the limited wireless resources are used among the plurality of terminal apparatuses. In such a situation, when many wireless resources are used in order to reduce the transmission time while a predetermined terminal apparatus is performing the file transfer, the streaming reproduction by other terminal apparatus may not be performed in a desired manner. Moreover, if a communication means between the base station apparatus and the terminal apparatus is wireless communication, it is possible that the characteristics of propagation paths may have an adverse effect on the communication.

SUMMARY OF THE INVENTION

The present invention has been made in recognition of the foregoing circumstances and an object thereof is to provide a method for allocating channels to a plurality of

terminals multiplexed by a base station apparatus, and provide a base station apparatus and a communication system utilizing said channel allocating method. Another object thereof is to provide a channel allocating method in

5 consideration of the types of application used, and a base station apparatus and a communication system utilizing said channel allocating method. Still another object thereof is to provide a method for allocating channels according to the current usage status of channels, and a base station

10 apparatus and a communication system utilizing said channel allocating method.

A preferred embodiment according to the present invention relates to a base station apparatus. This apparatus includes: a receiver which receives signals from a

15 terminal apparatus which is a targeted communication party; a permissible delay time detector which detects, from the signals received by the receiver, permissible delay time in data communication corresponding to an application used in the terminal apparatus; a decision unit which determines a

20 transmission rate per channel and the number of channels to be allocated to the terminal apparatus, in a communication line that contains a plurality of channels, according to the permissible delay time detected by the detector; and an instruction unit which instructs the terminal apparatus to

25 perform communication of data corresponding to the application by using the communication rate per channel and

the number of channels determined by the decision unit.

The "permissible delay time" is the allowable delay time but it is not limited to the time only, and may be other information associated with the delay time. For example, information may be that the application requires the real-timeness.

By implementing the above structure, the transmission rate per channel and the number of channels are determined based on the permissible delay time, so that the communication suitable for the application can be carried out.

Another preferred embodiment according to the present invention relates also to a base station apparatus. This apparatus includes: a receiver which receives signals from a terminal apparatus which is a targeted communication party; a permissible delay time detector which detects, from the signals received by the receiver, permissible delay time in data communication corresponding to an application used in the terminal apparatus; a quality detector which derives from the received signals a value indicative of the quality of a communication line; a decision unit which determines a transmission rate per channel and the number of channels to be allocated to the terminal apparatus, according to the permissible delay time detected by the detector, the value indicative of the quality of a communication line and a current channel usage rate in the communication line

containing a plurality of channels; and an instruction unit

which instructs the terminal apparatus to perform

communication of data corresponding to the application by

using the communication rate per channel and the number of

5   channels determined by the decision unit.

The decision unit may so determine that the

transmission rate per channel is raised and the number of

channels is reduced according to the derived value

indicative of the quality of a communication line if the

10   detected permissible delay time is greater than a

predetermined threshold value and that the transmission rate

per channel is lowered and the number of channels is

increased according to the channel usage rate if the

detected permissible delay time is less than or equal to the

15   predetermined threshold value.

By employing the above apparatus, the transmission

rate per channel and the number of channels are determined

based on the quality of the communication line and the

channel usage rate in addition to the permissible delay time.

20   Thus, the communication suitable for the application can be

carried out within the limited wireless resources.

Still another preferred embodiment according to the

present invention relates to a communication system. This

system includes: a terminal apparatus which uses a

25   predetermined application; and a base station apparatus

which communicates with the terminal apparatus via a

communication line containing a plurality of channels. In this system, the terminal apparatus transmits information on permissible delay time in data communication corresponding to the predetermined application to be used, and the base

5   station apparatus detects quality of the communication line and a channel usage rate and determines a transmission rate per channel and the number of channels to be allocated to the terminal apparatus based on the information on permissible delay time received from the terminal apparatus

10 together with the quality of the communication line and channel usage rate detected.

By employing the above system, the application in the terminal apparatus can be executed without any problem and further many terminal apparatuses can be multiplexed.

15   Still another preferred embodiment according to the present invention relates to a channel allocating method. This method is such that, based on permissible delay time in data communication corresponding to an application used in a terminal apparatus which is a targeted communication party,

20 a transmission rate per channel and the number of channels to be allocated to the terminal apparatus are determined for a plurality of channels contained in a communication line connected with the terminal apparatus.

Still another preferred embodiment according to the

25 present invention relates also to a channel allocating method. This method includes: receiving signals from a

terminal apparatus which is a targeted communication party;

detecting, from the signals received by the receiving,

permissible delay time in data communication corresponding

to an application used in the terminal apparatus;

5   determining a transmission rate per channel and the number

of channels to be allocated to the terminal apparatus, in a

communication line that contains a plurality of channels,

according to the permissible delay time detected by the

detecting; and instructing the terminal apparatus to perform

10   communication of data corresponding to the application by

using the communication rate per channel and the number of

channels determined by the determining.

    Still another preferred embodiment according to the

present invention relates also to a channel allocating

15   method. This method includes: receiving signals from a

terminal apparatus which is a targeted communication party;

detecting, from the signals received by the receiving,

permissible delay time in data communication corresponding

to an application used in the terminal apparatus; deriving

20   from the received signals a value indicative of the quality

of a communication line; determining a transmission rate per

channel and the number of channels to be allocated to the

terminal apparatus according to the permissible delay time

detected by the detecting, the derived value indicative of

25   the quality of a communication line and a current channel

usage rate in the communication line containing a plurality

of channels; and instructing the terminal apparatus to perform communication of data corresponding to the application by using the communication rate per channel and the number of channels determined by the determining.

5   The determining a transmission rate per channel and the number of channels may be such that the transmission rate per channel is raised and the number of channels is reduced according to the derived value indicative of the quality of a communication line if the detected permissible

10   delay time is greater than a predetermined threshold value and that the transmission rate per channel is lowered and the number of channels is increased according to the channel usage rate if the detected permissible delay time is less than or equal to the predetermined threshold value.

15   Still another preferred embodiment according to the present invention relates to a program. This program includes the functions of receiving signals from a terminal apparatus which is a targeted communication party; detecting, from the signals received by the receiving, permissible

20   delay time in data communication corresponding to an application used in the terminal apparatus; determining a transmission rate per channel and the number of channels to be allocated to the terminal apparatus, in a communication line that contains a plurality of channels, according to the

25   permissible delay time detected by the detecting; and instructing the terminal apparatus to perform communication

of data corresponding to the application by using the communication rate per channel and the number of channels determined by the determining.

Still another preferred embodiment according to the present invention relates also to a program. This program includes the functions of: receiving signals from a terminal apparatus which is a targeted communication party; detecting, from the signals received by the receiving, permissible delay time in data communication corresponding to an application used in the terminal apparatus; deriving from the received signals a value indicative of the quality of a communication line; determining a transmission rate per channel and the number of channels to be allocated to the terminal apparatus according to the permissible delay time detected by the detecting, the derived value indicative of the quality of a communication line and a current channel usage rate in the communication line containing a plurality of channels; and instructing the terminal apparatus to perform communication of data corresponding to the application by using the communication rate per channel and the number of channels determined by the determining.

In the program, the determining a transmission rate per channel and the number of channels may be such that the transmission rate per channel is raised and the number of channels is reduced according to the derived value indicative of the quality of a communication line if the

detected permissible delay time is greater than a predetermined threshold value and that the transmission rate per channel is lowered and the number of channels is increased according to the channel usage rate if the

5   detected permissible delay time is less than or equal to the predetermined threshold value.

It is to be noted that any arbitrary combination of the above-described structural components and expressions changed between a method, an apparatus, a system, a

10 recording medium, a computer program and so forth are all effective as and encompassed by the present embodiments.

Moreover, this summary of the invention does not necessarily describe all necessary features so that the invention may also be sub-combination of these described

15 features.

BRIEF DESCRIPTION OF THE DRAWINGS

20   FIG. 1 shows a communication system according to the present embodiment.

FIG. 2 shows a frame format according to the present embodiment.

FIG. 3 shows a structure of the terminal apparatus

25 shown in FIG. 1.

FIG. 4 shows a structure of the base station apparatus

shown in FIG. 1.

FIG. 5 shows relationships between a modulation method and a transmission rate for the number of channels in use.

FIG. 6 is a sequence diagram showing a procedure for allocating channels in the communication system shown in FIG. 1.

FIG. 7 is a flowchart showing a procedure for allocating channels in the base station apparatus shown in FIG. 4.

FIG. 8 is a flowchart showing a procedure for short delay time processing shown in FIG. 7.

FIG. 9 is a flowchart showing a procedure for long delay time processing shown in FIG. 7.

DETAILED DESCRIPTION OF THE INVENTION

The invention will now be described based on the following embodiments which do not intend to limit the scope of the present invention but exemplify the invention. All of the features and the combinations thereof described in the embodiments are not necessarily essential to the invention.

The present embodiment relates to a base station apparatus capable of accessing a plurality of terminal apparatuses. A frame generated by the base station

apparatus contains a plurality of channels and each of the channels is allocated to a predetermined terminal apparatus. The transmission rate per channel, namely, a modulation method adopted in the base station apparatus and the

5   terminal apparatus, is set in such a manner that it can be varied. On the other hand, a predetermined application is being used in a PC connected to the terminal apparatus, and the terminal apparatus notifies the base station apparatus about permissible delay time of data communicated for the

10 application. The base station apparatus according to the present embodiment determines a modulation method and the number of channels for the terminal apparatus, according to the thus notified permissible delay time, and then allocates the thus determined channels to the terminal apparatus.

15 That is, in a case when the permissible delay time set for the data in the application is small, a modulation method, such as BPSK (Binary Phase Shift Keying), which is rather robust against the error, is adopted in a video conference system, for instance, so that the large number of channels

20 is allocated and the retransmission of data is reduced. In a case when the permissible delay time set for the data in the application is large, a modulation method, such as 16QAM, which can transmit a large amount of data is adopted in a file transfer, for instance, so that the small number of

25 channels is allocated and other terminal apparatuses can be connected to the base station apparatus.

In the wireless communication between base station apparatus and terminal apparatuses, the characteristics of a transmission path affects the decision-making of a modulation type, and in the base station that are being

5   connected with a plurality of terminal apparatuses the number of channels which has been already allocated affects the decision-making of the number of channels to be allotted. Thus, the base station apparatus according to present embodiment detects communication quality and channel usage

10   rate, in addition to the above-described permissible delay time, and takes all of these into consideration.

FIG. 1 shows a communication system 100 according to the present embodiment. The communication system 100 includes a PC 10, a terminal apparatus 12, a terminal

15   antenna 14, a basestation antenna 16, and a base station apparatus 18 and a network 20.

The PC 10 executes a predetermined application in accordance with an instruction from a user. The application includes a video conference system, moving image

20   reproduction, file transfer, Web browser and so forth.

The terminal apparatus 12 is a radio unit connected to the PC 10, and further includes a terminal antenna 14 and is connected to a base station apparatus 18 (described later) with which the data necessary for the application of the PC

25   10 is communicated. Though a single terminal apparatus 12 only is shown in FIG. 1, a plurality of PCs 10 may be

included in the communication system 100.

The base station apparatus 18 is a radio unit which can communicate with a plurality of terminal apparatuses by allocating predetermined channels to the respective terminal apparatuses 12. Further, the base station apparatus 18 has a basestation antenna 16 by which to access and get connected with the terminal apparatuses 12.

FIG. 2 shows a frame format according to the present embodiment. The frame format shown in FIG. 2 is the same as one for a personal handyphone system (PHS); a single frame is constituted by eight channels. Among the eight channels, the four channels are used for the down link whereas the remaining four channels are used for the up link. The modulation method for a channel is set separately from other channels. Hereinafter, it is assumed for the brevity that the modulation method to be set is any one of BPSK (Binary Phase Shift Keying), $\pi/4$ shift QPSK (Quadrature Phase Shift Keying) and 16QAM (16 Quadrature Amplitude Modulation).

FIG. 3 shows a structure of the terminal apparatus 12. The terminal apparatus 12 includes a storage 22, an RF unit 24, a demodulator 26, a modulator 28, a quality detector 30 and a control unit 32. The control unit includes 32 a modulation method and channels detector 34 and an instruction unit 36. The storage 22 includes a quality information unit 42, an application information unit 44, a modulation method information unit 46 and a channels

information unit 48. The PC 10 includes application software 38, and the application software 38 includes an application notifying unit 40.

The RF unit 24 performs a processing between a
5   baseband signal and a radio frequency signal which are processed by the modulator 28 or demodulator 26 (described later). Here, the processing includes a frequency conversion, an amplification processing, an A-D or D-A conversion and so forth.

10   The demodulator 26 performs a demodulation processing on a received signal which has been converted to a baseband by the RF unit 24. It is assumed here that the demodulation processing also changes according to the modulation method adopted for the received signal. For example, the modulated
15   signal is coherent-detected in the 16QAM whereas it is differential-detected in the $\pi/4$ shift QPSK. Moreover, it is assumed here that the demodulator 26 further includes a carrier synchronous circuit and an AFC (Automatic Frequency Control) unit necessary for the synchronous detection.

20   The quality detector 30 measures the line quality of a telecommunication line or communication network. The line quality may be arbitrary, and it may be, for example, a received power, a ratio of desired wave power over interference power, a delay spread, a bit error rate (BER)
25   and so forth. Moreover, the quality detector 30 gathers information on the measured line quality and stores the

SA-70111

information in the quality information unit 42 (described

later) of the storage 22. It is to be noted that the

quality detector 30 will not be necessary if the line

quality of the up link only is measured and the line quality

5   of the down link is assume equivalent to that of the up link.

The modulation method and channels detector 34 detects

a modulation method and channel usage information set within

a message contained in the received signals from the base

station apparatus 18, and stores them in the modulation

10 method information unit 46 (described later) and the

channels information unit 48 (described later) of the

storage 22, respectively.

The application software 38 is software run on the PC,

and is located on upper-layer protocol in the terminal

15 apparatus 12.

The application notifying unit 40 is contained in the

application software 38. The application notifying unit 40

notifies the control unit 32, which controls a lower layer

protocol of the application software 38, of application

20 information. The application information contains

information on the permissible delay time. The information

includes information on the permissible delay time itself,

software classification information corresponding to the

permissible delay time and so forth. As examples of the

25 software classification information, there are type 1 in

which the permissible delay time is small and type 2 in

which the permissible delay time is large.

The storage 22 is a storage medium which stores various information, and is comprised of a quality information unit 42, an application information unit 44, a

5   modulation method information unit 46 and a channels information unit 48. The quality information unit 42 stores information on the line quality measured by the quality detector 30. The application information unit 44 stores application information notified from the application

10 notifying unit 40. The modulation method information unit 46 and the channels information unit 48 store the modulation method and the channel usage information detected by the modulation method and channels detector 34, respectively. It is to be noted that the storage 22 may be provided inside

15 the terminal apparatus 12.

The instruction unit 36 sets, within a message to be sent to the base station apparatus 18, the application information notified from the application notifying unit 40 and the information on the line quality measured by the

20 quality detector 30.

The modulator 28 performs a modulation processing on the message set by the instruction unit 36 and the data of application software 38. As the information on the modulation method and the number of channels to be used for

25 the modulation processing, used is the information stored in the modulation method information unit 46 and the channels

information unit 48, respectively.

In addition to the above-described operations, the control unit 32 analyzes the received demodulation data and operates according to the analyzed result and carries out

5   the operations of establishing a connection, controlling the timing thereof and so forth.

In terms of hardware, the above-described structure can be realized by a CPU, a memory and other LSIs of an arbitrary computer. In terms of software, it can be

10   realized by memory-loaded programs which have managing and scheduling functions or the like, but drawn and described here are function blocks that are realized in cooperation with those. Thus, it is understood by those skilled in the art that these function blocks can be realized in a variety

15   of forms by hardware only, software only or the combination thereof.

FIG. 4 shows a structure of a base station apparatus 18. The base station apparatus 18 includes an RF unit 50, a demodulator 52, a modulator 54 and a quality detector 56, a

20   control unit 58, a network interface unit 60, and a storage 62. The control unit 58 includes an instruction unit 64, a modulation method and channels determining unit 66, an application detector 68 and a usage rate detector 70. The storage 62 includes a quality information unit 72, a usage

25   rate information unit 74, an application information unit 76 and a modulation method information unit 78.

The RF unit 50 performs a processing between a baseband signal and a radio frequency signal which are processed by the modulator 54 or demodulator 52 (described later). Here, the processing includes a frequency

5　conversion, an amplification processing, an A-D or D-A conversion and so forth.

The demodulator 52 performs a demodulation processing on a received signal which has been converted to a baseband by the RF unit 50. It is assumed here that, similar to the

10　demodulator 26 described above, the demodulation processing is also changed according to the modulation method adopted for the received signal.

The quality detector 56 detects the line quality of a communication network, and measures the line quality of a

15　down link by detecting information on the line quality set in a message within a received signal from the terminal apparatus 12. As for the line quality of an up link, measured by an arbitrary means are, for example, a received power, a ratio of desired wave power over interference power,

20　a delay spread, a bit error rate (BER) and so forth. Moreover, the quality detector 56 gathers information on the measured line qualities and stores the information in the quality information unit 72 (described later) of the storage 62. It is to be noted that only one of the above processing

25　is carried out if it suffices to measure either the line quality on up link or down link.

The application detector 68 detects application information set in a message within received signals from the terminal apparatus 12. Moreover, the application detector 68 stores the thus detected application information in the application information unit 76 (described later) of the storage 62.

The storage 62 is a storage medium which stores various information, and is comprised of a quality information unit 72, a usage rate information unit 74, an application information unit 76 and a modulation method information unit 78. The quality information unit 72 stores information on the line quality detected by the quality detector 56. The application information unit 76 stores application information notified from the application detector 68. The usage rate information unit 74 and the modulation method information unit 78 store the usage information and the modulation method which are scheduled by the control unit 58, respectively. It is to be noted that the storage 62 may be provided inside the base station apparatus 18.

The usage rate detector 70 detects the current channel usage rate from the usage rate information unit 74 in the storage 62. The channel usage rate may be the number of channels being currently in use.

Based on the application information notified from the application detector 68 and the information on the detected

line quality notified from the quality detector 56 and the

channel usage rate notified from the usage rate detector 70,

the modulation method and channels determining unit 66

determines both the modulation method and the number of

5   channels to be allocated to a communicating party. The

details of how to determine them will be described later.

The instruction unit 64 carries out the scheduling of

a plurality of terminal apparatuses 12 based on the

modulation method and the number of channels determined by

10   the modulation method and channels determining unit 66.

Moreover, the instruction unit 64 sets, within a message to

be sent to the terminal apparatus 12, the information on the

determined modulation method and the number of channels.

The network interface unit 60 is an interface with a

15   network 20.

In addition to the above-described operations, the

control unit 58 analyzes the received demodulation data and

operates according to the analyzed result and carries out

the operations of establishing a connection, controlling the

20   timing thereof and so forth.

FIG. 5 shows relationships between a modulation method

and a transmission rate for the number of channels in use.

As was mentioned above, the modulation method used here is

among BPSK, $\pi/4$ shift QPSK and 16QAM, so that there are

25   shown the transmission rates realized when the number of

channels used is varied according to the modulation method.

For example, the transmission rate will be 16 Kbps when a single channel is assigned to the BPSK whereas it will be 256 Kbps when four channels are assigned to the 16QAM.

FIG. 6 is a sequence diagram showing a procedure for allocating channels. The base station apparatus 18 transmits a control signal to a plurality of terminal apparatuses 12 (S10). The instruction unit 36 in the terminal apparatus 12 sets application information in a message (S12). The terminal apparatus 12 transmits to the base station apparatus 18 an LCH establishment request, namely, a request for allocation of channels for use with a communication (S14). The base station apparatus 18 notifies the terminal apparatus 12 of an LCH assignment (S16). The terminal apparatus 12 sends a synchronization burst to the base station apparatus 18 (S18), and the base station apparatus 18 sends the synchronization burst to the terminal apparatus 12 (S20). The instruction unit 36 in the terminal apparatus 12 sets the information on line quality in the message (S22). The terminal apparatus 12 transmits a modulation method allocating request to the base station apparatus 18 (S24). The base station apparatus 18 determines a modulation method and the number of channels in use by the modulation method and channels determining unit 66, and the instruction unit 64 in the base station apparatus 18 sets the thus determined result in the message (S26). The base station apparatus 18 transmits to the

terminal apparatus 12 a modulation method allocation notice

contained in the message (S26). After the message of

synchronization establishment has been notified from the

terminal apparatus 12 to the base station apparatus 18 (S30),

5   a communication processing to use an application is

performed between the terminal apparatus 12 and the base

station apparatus 18 (S32).

     FIG. 7 is a flowchart showing a procedure for

allocating channels. The modulation method and channels

10   determining unit 66 shown in FIG. 4 compares the permissible

delay time in the application information notified from the

application detector 68 to a threshold value. Instead, the

comparison may be made based on classification information

on application in the application information. If the

15   permissible delay time of the application is less than or

equal to a threshold value (Y of S40), a processing for

short delay time is performed (S42). If the permissible

delay time of the application is not less than or equal to

the threshold value (N of S40), a processing for long delay

20   time is performed (S44). The details on the short delay

time processing and long delay time processing will be

described later.

FIG. 8 is a flowchart showing a procedure for short delay

time processing. The modulation method and channels

25   determining unit 66 shown in FIG. 4 checks on the number of

unoccupied channels, based on the channel usage rate

notified from the usage rate detector 70. If the number of unoccupied channels is four or more (Y of S50), the modulation method and channels determining unit 66 allocates four channels to the terminal apparatus 12, which is to be

5 communicated with, by using BPSK as the modulation method (S52). If, on the other hand, the number of unoccupied channels is not more than four (N of S50) and it is two or three (Y of S54) and if the $\pi/4$ shift QPSK is available (Y of S56), $\pi/4$ shift QPSK is allocated to the two channels as

10 the modulation method, based on the information on the line quality 0051]

If the $\pi/4$ shift QPSK is not available (N of S56), two or three channels are assigned with the modulation method of BPSK (S60). If, on the other hand, the number of unoccupied

15 channels is not two or three (N of S54) and 16QAM is usable (Y of S66), one channel is assigned with the modulation method of 16QAM (S64). If 16QAM is not available (N of S62) and $\pi/4$ shift QPSK is available (Y of S66), one channel is assigned with the modulation method of $\pi/4$ shift QPSK. If

20 16QAM is not available (N of S62) and $\pi/4$ shift QPSK is also not available (N of S66), one channel is assigned with the modulation method of BPSK (S70).

FIG. 9 is a flowchart showing a procedure for long delay time processing. If 16QAM is available (Y of S80),

25 the modulation method and channels determining unit 66 shown

in FIG. 4 allocates, based on information on the line quality notified from the quality detector 56, one channel to the terminal apparatus 12, which is a targeted communication party, by using 16QAM as the modulation method

5 (S82). If 16QAM is not available (N of S80) and $\pi/4$ shift QPSK is available (Y of S84), the number of unoccupied channels is examined based on the channel usage rate notified from the usage rate detector 70. As a result, if the number of unoccupied channels is two or more (Y of S86),

10 $\pi/4$ shift QPSK is allocated to two channels as the modulation method (S88). If, however, the number of unoccupied channels is not two or more (N of S86), one channel $\pi/4$ shift QPSK is allocated (S90).

If, on the other hand, $\pi/4$ shift QPSK is not available

15 (N of S84) and the number of unoccupied channels is four or more (Y of S92), then four channels are assigned with the modulation method of BPSK (S88). If the number of unoccupied channels is not four or more (N of S92) and it is two or three (Y of S96), then two or three channels are

20 assigned with the modulation method of BPSK (S98). And if the number of unoccupied channels is not two or three (N of S96), one channel is assigned with the modulation method of BPSK (S100).

An operation for the communication system 100

25 structured as above will be described hereinbelow. In the

terminal apparatus 12, the line quality based on the

received signals from the base station apparatus 18 and the

application information from the application software 38 are

simultaneously or separately set in a message so as to be

5   transmitted to the base station apparatus 18. In the

modulation method and channels determining unit 66 in the

base station apparatus 18, the allocation of the modulation

method and the number of channels is determined according to

the line quality, application information and channel usage

10   rate detected. For example, if the permissible delay time

is shorter than the threshold value and the number of

unoccupied channels is two and the communication can be done

by $\pi/4$ shift QPSK, then two channels are assigned with the

modulation method of $\pi/4$ shift QPSK. Then, the instruction

15   unit 64 notifies the terminal apparatus of this allotment

result.

According to the present embodiments, the allocation

of the modulation method and the number of channels is

determined according to the permissible delay time that

20   corresponds to the kind of application in question. Thus,

if the permissible delay time is small, the larger number of

channels is used together with a modulation method which can

keep the error rate lower. Similarly, if the permissible

delay time is large, the smaller number of channels is used

25   together with a modulation method which can transmit a large

amount of data. As a result thereof, the multiplexing of a

plurality of terminal apparatuses can be done while

satisfying the permissible delay time.

The present invention has been described based on the

embodiments which are only exemplary. It is understood by

5   those skilled in the art that there exist other various

modifications to the combination of each component and

process described above and that such modifications are

encompassed by 0057]

In the present embodiments, the communication system

10   100 implements TDMA (Time Division Multiple Access), but the

multiple access method is not limited thereto. For example,

FDMA (Frequency Division Multiple Access) or CDMA (Code

Division Multiple Access) may also be used. And the present

invention may be applied to wide range of embodiments. In

15   other words, the present embodiments may be applied as long

as a base station multiplexes a plurality of terminals.

In the present embodiments, a transmission rate per

channel is determined by a modulation method only, and the

modulation method and channels determining unit 66

20   determines the modulation method alone. However, the

present embodiments are not limited thereto, and the coding

rate in error correction may be considered, for example. In

this modified example, the transmission rate can be set more

finely. In other words, a factor or factors to be taken

25   into consideration may be any term which determines and/or

affects the transmission rate. For example, if three types

of modulation methods and four kinds of coding rates are prepared, then the total of twelve different transmission rates will be available.

Although the present invention has been described by way of exemplary embodiments, it should be understood that many changes and substitutions may further be made by those skilled in the art without departing from the scope of the present invention which is defined by the appended claims.